#1235

1235

February 11, 1992

PROGRESS REPORT

USE OF PHEROMONES TO INCREASE INTERSPECIFIC COMPETITION BETWEEN SPRUCE BEETLES AND OTHER BARK BEETLES (SCOLYTIDAE) INHABITING WHITE, LUTZ, AND SITKA SPRUCE IN ALASKA

Richard A. Werner
Institute of Northern Forestry
Pacific Northwest Research Station
Fairbanks, Alaska

Introduction

The spruce beetle, Dendroctonus rufipennis (Kirby), infests most species of Picea in north America. White spruce, Sitka spruce and the hybrid Lutz spruce are the major hosts in Alaska (Schmid and Frye 1977; Werner et al. 1977). Past outbreaks in south-central Alaska have been associated with warm, dry summers and an accumulation of spruce debris from windthrown and felled trees which are highly productive breeding sites for SBs. When beetle populations increase and a sufficient supply of breeding material is no longer available for colonization, beetles can infest nearby living trees, particularly in mature stands (Werner et al. 1977, Werner and Holsten 1983).

Presently, the strategies developed to mitigate the effects of SB on spruce stands in Alaska involve some form of stand manipulation or the use of chemical insecticides (Werner et al. 1977, Werner 1978). Among the recommended techniques for treatment of logging slash, felled, or windthrown green trees is the immediate salvage of the trees; or disposing by burning, chipping, or burying; or treating with EPA approved insecticides (Werner et al. 1983, 1984, 1986); or use of pheromone-baited traps (Werner 1988). The use of pheromones to effectively manage populations of SB needed to be examined using several operational use strategies such as interspecific competition in pheromone-baited trap trees, and trap-out, spot baiting, and diversion trapping using funnel traps and trap trees. This study investigated the feasibility of using competing species of bark beetles as a management tool based on past research.

Field studies conducted from 1980-1991 in south-central and interior Alaska identified several scolytid pheromones and host terpenes (semiochemicals) such as seudenol, frontalin, and alpha pinene as aggregants for D. rufipennis and D. simplex (Werner et al. 1981, unpublished data). Frontalin dispersed from sticky traps also caught Dryocoetes affaber, D. autographus, Pityophthorus nitidulus, and Polygraphus rufipennis. A slow release ternary formulation of alpha pinene + frontalin + 1-methylcyclohex-2-enol (MCOL) (RR=0.7 mg/day, 0.1 mg/day, and 0.5 mg/day, respectively) caught significantly more SB than the binary formulation of alpha pinene + frontalin (RR=0.7 and 0.1 mg/day,

#1235

respectively) (Wieser et al. 1989). Field trapping experiments in interior Alaska indicated that racemic ipsdienol caught more Ips borealis, I. perturbatus, and I. tridens tridens in sticky traps and trap trees than racemic ipsenol and a combination of both (Werner and Holsten 1984, unpublished data).

Attracting competing bark beetles to suitable SB hosts may interfere with SB development and survival. Thomson and Sahota (1981) showed that competition effects parent beetles during egg gallery establishment resulted in reduction in gallery length and oviposition. Safranyik and Linton (1985) demonstrated that density-dependent compensatory processes operate in SB populations during egg gallery construction and brood development when such populations compete for space. Whitmore (1983) reported that the most important arthropod factor impacting populations of SB was interspecific competition with other species of scolytids. The frequency of scolytid species co-occurrence within a discrete area of the phloem is a useful indicator of their potential for competition (Paine et al. 1981). Whitmore (1983) also reported that small scolytid species were competing with SB in 73% of the bark samples (100 cm^2) in which SB were found. Dryocoetes affaber and Polygraphus rufipennis were the most important scolytid competitors found in felled spruce.

Objectives

1. To test the feasibility of using scolytid pheromones to increase interspecific competition with SB in order to reduce SB brood establishment.

Materials and Methods

Study Areas

A stand of Lutz spruce on the Chugach NF in south-central Alaska and white spruce in the Bonanza Creek Experimental Forest near Fairbanks in interior Alaska were used for this study. Spruce stands contained mature spruce with an epidemic population in south-central and an endemic population in interior.

Treatments

anti-aggreg. of Dry. affaber??

The experiment utilized four different scolytid pheromones.

1. SB = alpha pinene (RR=0.7 mg/day) + frontalin (RR=0.1 mg/day), polybag.
2. Polygraphus sp. = 3-methyl-3-buten-1-ol, racemic, 0.5 g loading (RR=3.8 mg/day), bubblecap.
3. Dryocoetes sp. = exo-brevicomin, 400 ul loading (RR=2.5 mg/day), bubblecap

should be testing endo-

4. Ips sp. = ipsdienol, racemic (RR=0.2 mg/day), 20 mg bubblecaps.

Experimental Design

Twelve treatments were replicated 5 times in a complete randomized design. Lures were dispersed from 12-unit Lindgren funnel traps (50 traps/site) which were hung from a rope suspended between two trees at a height of 6.5 feet with the collection container of each trap one foot from ground level. Traps were

located at 50-foot intervals. Traps were checked weeky and beetles collected and stored in alcohol in glass vials until counted.

Treatment Combinations

spruce beetle (S)
methyl butenal (M)
exo-brevicomin (E)
ipsdienol, racemic (I)
S x M
S x E
S x I
S x M x E
S X M X I
S X E X I
S x M x E x I
unbaited control

Statistical Analyses

Data were transformed using arc sine to overcome variations due to zero counts. Total number of beetles caught per species for each of the treatments were subjected to an ANOVA using treatments = 11, error = 48, total = 59. Differences between means were tested using Tukey's Studentized Range (HSD) test (Tukey 1953).

Results

SB populations in the interior site were too low to obtain any significant effects from competing bark beetle pheromones. Exo-brevicomin was effective in attracting *Dryocoetes* to traps baited with the pheromone by itself or in combination with the other three pheromones except the S x P x D x I which caught significantly fewer *Dryocoetes*.

SB populations in the south-central site were extremely high. The SB pheromone (alpha pinene + frontalin + MCOL) tested alone and in combination with racemic ipsdienol caught the most SB beetles. Ipsdienol in combination with SB pheromone caught the most *Ips* but did not reduce the number of SB caught compared to SB pheromone alone. *Polygraphus* pheromone (methul butenol) caught more *Ips* and *Dryocoetes* than *Polygraphus* species. The addition of methyl butenol to SB pheromone and exo-brevicomin to SB pheromone resulted in decreased SB catches compared with SB pheromone-baited traps. The combination of SB pheromone + methyl butenol + exo-brevicomin, and SB pheromone + exo-brevicomin + ipsdienol caught the lowest number of SB and compared with the same catch as unbaited control traps. The addition of methyl butenol or exo-brevicomin to any of the treatments resulted in a slight decrease in SB catch but the addition of both methyl butenol and exo-brevicomin reduced SB catch to the lowest numbers. Ipsdienol had no significant effect on beetle catch. The success of the test in reducing SB catch can be summarized as follows: S x P x D = S x D x I > S x P x I = S x D = S x P x D x I > S x P.

Literature Cited

Holsten, Edward H., Werner, Richard A. 1990. Comparison of white, Sitka, and Lutz spruce as hosts of the spruce beetle in Alaska. Can. J. For. Res. 20: 292-297.

Paine, T.D.; Birch, M.C.; Svihra, P. 1981. Niche breadth and resouirce partitioning by four sympatric species of bark beetles (Coleoptera: Scolytidae). Oecologia (Berlin), 48: 1-6.

Safranyik, L.; Linton, D.A. 1985. Influenece of competition on size, brood production and sex ratio in spruce beetles (Coleoptera: Scolytidae). J. Entomol. Soc. Brit. Columbia 82: 52-56.

Schmid, J.M., Frye, R.H. 1977. Spruce beetle in the Rockies. Gen Tech. Rep. RM-49. Fort Collins, CO: U.S. Department of Agriculrure, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.

Thomson, A.J.; Sahota, T.S. 1981. Competition and population quality in Dendroctonus rufipennis (Coleoptera: Scolytidae). Can. Entomol. 113: 177-183.

Tukey, J.W. 1953. The problem of multiple comparisons. Ditto, princetin University, Princeton, NJ.

Werner, R.A. 1978. The spruce beetle in Alaska Forests. U.S. Forest Service Brochure. (Guidelines for reducing spruce beetle attack in areas of Alaska with high value white spruce trees.)

Werner, Richard A. 1988. Recommendations for suppression of an Ips perturbatus outbreak in interior Alaska using integrated control. IUFRO Working Party, 3-8 July, 1988, Vancouver, BC. 3-8 July, 1988.

Werner, R.A.; Holsten, E.H. 1983. Mortality of white spruce during a spruce beetle outbreak on the Kenai Peninsula in Alaska. Can. J. For. Res. 13: 96-101.

Werner, Richard A., Holsten, E.H. 1984. Scolytidae associated with felled white spruce in Alaska. Can. Entomol. 116: 465-471.

Werner, R.A., Baker, B.H., Rush, P.A. 1977. The spruce beetle in white spruce forests of Alaska. Gen Tech. Rep. PNW-61. Portland OR: U.S. Department of Agriculture, Forest Service, Pacific Forest Research Station. 13 p.

Werner, Richard A.; Furniss, Malcom, M.; Yarger, Larry, C.; Ward, Thomas. 1981. Effects on eastern larch beetle of its natural attractant and synthetic pheromones in Alaska. PNW-RN-371. Portland, OR: U.S. Dept. of Agric. For Serv. 7 p.

Werner, R.A.; Hastings, F.L.; Averill, R. 1983. Laboratory and field evaluation of insecticides against the spruce beetle (Coleoptera: Scolytidae). Journal of Economic Entomology. 76: 1144-1147.

Werner, Richard A.; Averill, Robert D.; Hastings, Felton L.; Hilgert, Jerry W.; Brady, U.E. 1984. Field evaluation of fenitrothion, permethrin, and chlorpyrifos for protecting white spruce trees from spruce beetle (Coleoptera: Scolytidae) attack in Alaska. Journal of Economic Entomology. 77(4): 995-998.

Werner, Richard A.; Hastings, Felton L.; Holsten, Edward H.; Jones, Alice S. 1986. Carbaryl and lindane protect white spruce from attack by spruce beetles (Coleoptera: Scolytidae) for three growing seasons. Journal of Economic Entomology. 79(4): 1121-1124.

Whitmore, Mark, C. 1983. The predators and parasites affecting scolytid populations from white spruce in Alaska. MS Thesis. University of Washington, Seattle. 95 p.

Table 1. Mean number of scolytids caught in funnel traps by various bark beetle pheromones alone and in combination, interior Alaska, 1991

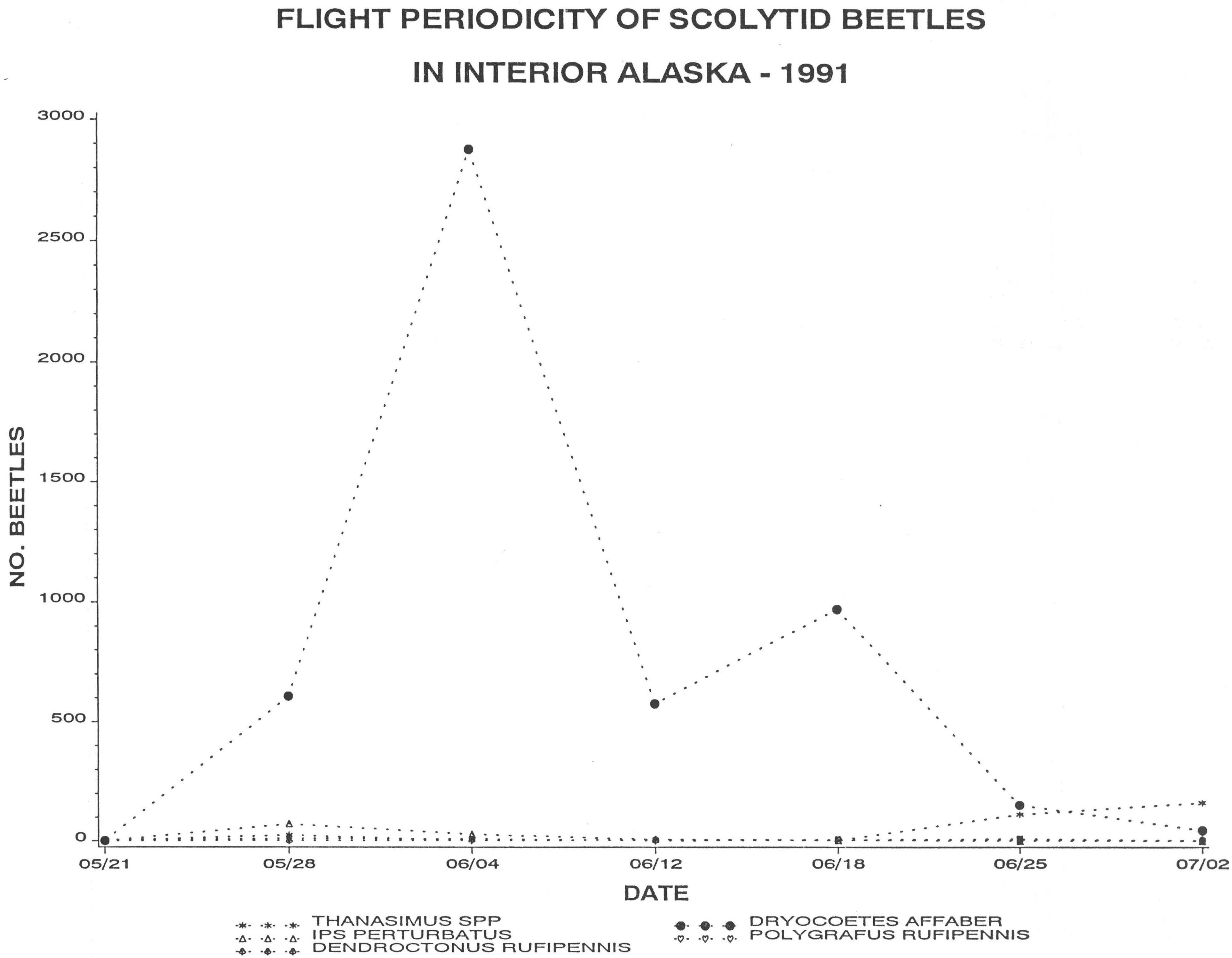
Treatment	Mean ± SD			
	Spruce beetle	Polygraphus	Dryocoetes	Ips
Spruce beetle (S)	0.13 ± 0.34a	0.03 ± 0.18a	6.47 ± 36.59bc	0.00 ± 0.00b
Polygraphus (P)	0.00 ± 0.00a	0.00 ± 0.00a	0.03 ± 0.18c	0.00 ± 0.00b
Dryocoetes (D)	0.06 ± 0.25a	0.03 ± 0.18a	34.09 ± 54.06a	0.00 ± 0.00b
Ips (I)	0.00 ± 0.00a	0.00 ± 0.00a	0.03 ± 0.18c	0.41 ± 0.98ab
S X P	0.06 ± 0.25a	0.09 ± 0.30a	0.00 ± 0.00c	0.03 ± 0.18b
S X D	0.16 ± 0.37a	0.28 ± 1.11a	31.62 ± 47.53ab	0.03 ± 0.18b
S X I	0.03 ± 0.18a	0.06 ± 0.35a	0.91 ± 1.94c	0.66 ± 1.52ab
S X P X D	0.00 ± 0.00a	0.34 ± 1.04a	30.41 ± 45.92ab	0.00 ± 0.00b
S X P X I	0.06 ± 0.25a	0.00 ± 0.00a	1.06 ± 2.42c	0.66 ± 1.29ab
S X D X I	0.03 ± 0.18a	0.22 ± 1.07a	36.28 ± 58.18a	0.53 ± 1.34ab
S X P X D X I	0.03 ± 0.18a	0.03 ± 0.18a	22.31 ± 35.45bc	1.03 ± 2.53a
Control	0.03 ± 0.18a	0.00 ± 0.00a	0.00 ± 0.00c	0.00 ± 0.00b

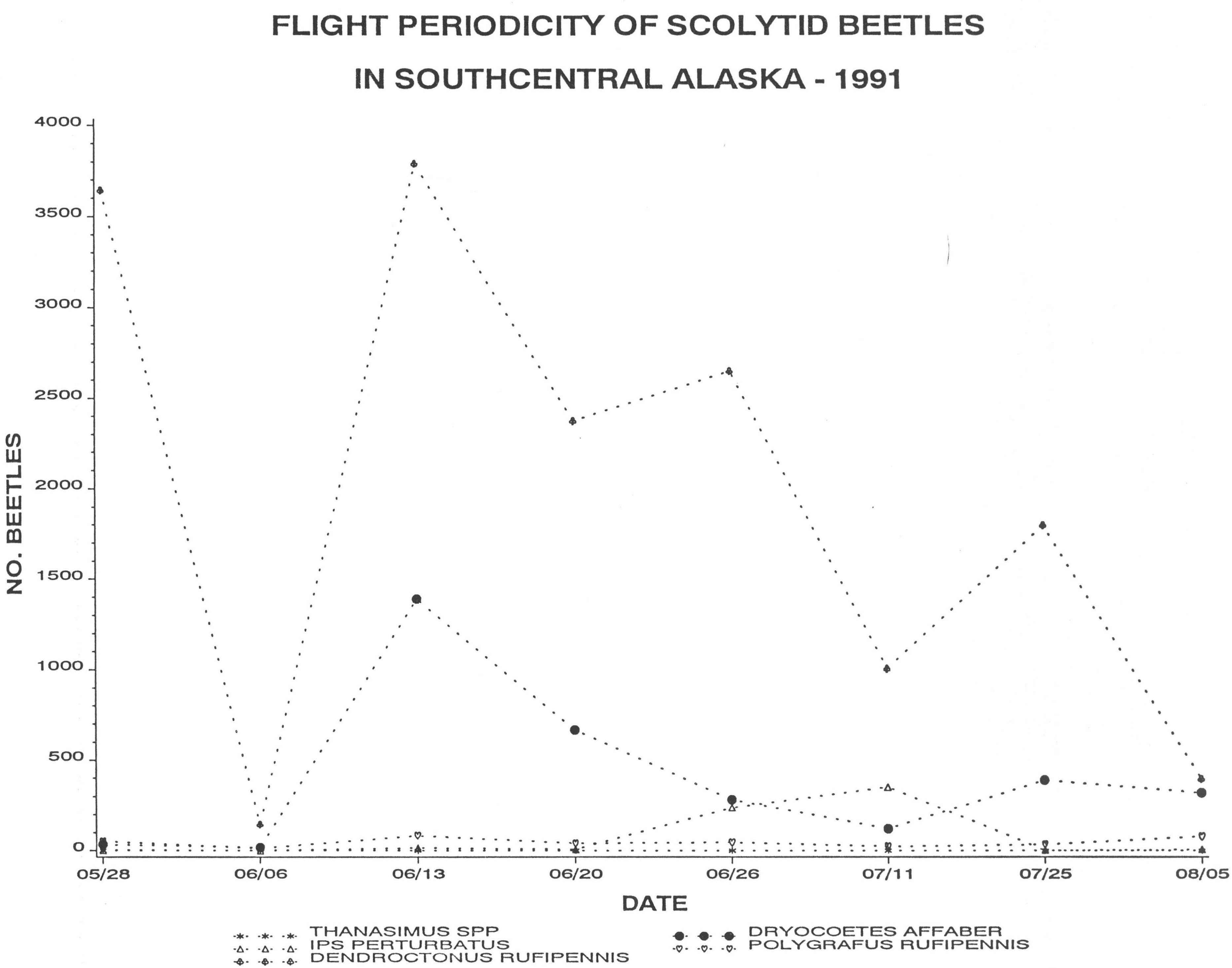
Means within columns followed by the same letter are not significantly different ($P<0.05$, Tukey's Studenized Range Test [HSD] [Tukey 1953]).

Table 2. Mean number of scolytids caught in funnel traps by various bark beetle pheromones alone and in combination, south-central Alaska, 1991

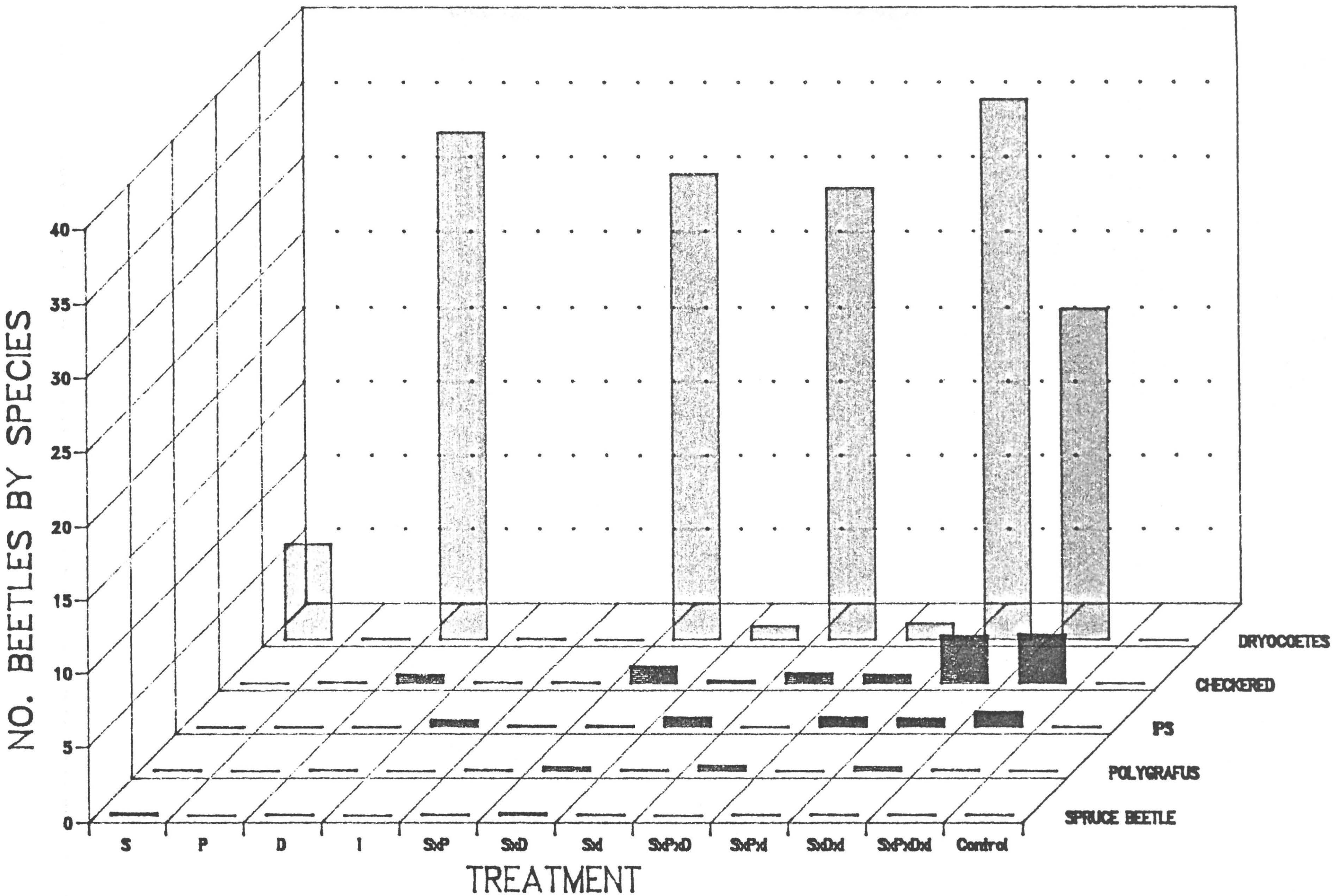
	Mean ± SD			
Treatment	Spruce beetle	Polygraphus	Dryocoetes	Ips
Spruce beetle (S)	141.8 ± 223.8a	0.59 ± 1.32b	6.62 ± 36.2b	0.00 ± 0.00b
Polygraphus (P)	25.7 ± 37.7b	0.25 ± 0.67b	0.63 ± 1.8b	0.06 ± 0.25b
Dryocoetes (D)	1.7 ± 2.1c	1.16 ± 2.34b	16.00 ± 32.2a	0.03 ± 0.18b
Ips (I)	24.6 ± 41.8b	1.28 ± 2.82a	1.28 ± 2.7b	0.25 ± 0.51b
S X P	55.8 ± 68.6b	1.06 ± 1.93b	1.25 ± 2.0b	0.31 ± 0.82b
S X D	28.5 ± 44.5b	3.00 ± 4.66a	21.00 ± 47.8a	0.03 ± 0.18b
S X I	94.2 ± 150.6ab	0.47 ± 1.27b	3.44 ± 17.1b	17.97 ± 70.43a
S X P X D	19.2 ± 25.0c	0.91 ± 1.25b	11.50 ± 25.1ab	0.00 ± 0.00b
S X P X I	30.8 ± 60.8b	0.38 ± 0.75b	2.12 ± 4.4b	0.41 ± 0.91b
S X D X I	17.9 ± 42.6c	0.44 ± 0.72b	13.84 ± 24.9ab	0.06 ± 0.25b
S X P X D X I	47.3 ± 75.2b	1.59 ± 3.35a	22.66 ± 53.8a	0.16 ± 0.57b
Control	6.7 ± 10.4c	0.38 ± 0.83b	0.16 ± 0.5b	0.03 ± 0.18b

Means within columns followed by the same letter are not significantly different ($P<0.05$, Tukey's Studenized Range Test [HSD] [Tukey 1953]).


FLIGHT PERIODICITY OF SCOLYTID BEETLES
IN INTERIOR ALASKA - 1991
NO. BEETLES
3000
2500
2000
1500
1000
500
0
05/21
05/28
06/04
06/12
06/18
06/25
07/02
DATE
THANASIMUS SPP
IPS PERTURBATUS
DENDROCTONUS RUFIPENNIS
DRYOCOETES AFFABER
POLYGRAFUS RUFIPENNIS


FLIGHT PERIODICITY OF SCOLYTID BEETLES
IN SOUTHCENTRAL ALASKA - 1991
NO. BEETLES
4000
3500
3000
2500
2000
1500
1000
500
0
05/28
06/06
06/13
06/20
06/26
07/11
07/25
08/05
DATE
THANASIMUS SPP
IPS PERTURBATUS
DENDROCTONUS RUFIPENNIS
DRYOCOETES AFFABER
POLYGRAFUS RUFIPENNIS

EFFECT OF SCOLYTID PHEROMONES ON BEETLE RESPONSE, FAIRBANKS 1991



EFFECT OF SCOLYTID PHEROMONES ON BEETLE RESPONSE, ANCHORAGE 1991